Non-destructive testing of steel tubes —

Part 3: Automatic eddy current testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of imperfections

The European Standard EN 10246-3:1999 has the status of a British Standard

ICS 23.040.10; 77.040.20

National foreword

This British Standard is the official English language version of EN 10246-3:1999.

This British Standard contains elements of BS 3889-1:1983. A complete list of the parts of EN 10246 is given in annex A of this standard. This British Standard partially supersedes BS 3889-1:1983, and when all relevant parts have been published BS 3889-1:1983 will be withdrawn.

The UK participation in its preparation was entrusted by Technical Committee ISE/73, Steels for pressure purposes, to Subcommittee ISE/73/1, Steel tubes for pressure purposes, which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Cross-references

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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 14, an inside back cover and a back cover.

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Non-destructive testing of steel tubes – Part 3: Automatic eddy current testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of imperfections

Essais non destructifs des tubes en acier – Partie 3: Contrôle automatique par courants de Foucault pour la détection des imperfections des tubes en acier sans soudure et soudés (sauf à l'arc immergé sous flux en poudre)

Zerstörungsfreie Prüfung von Stahlrohren – Teil 3: Automatische Wirbelstromprüfung nahtloser und geschweißter (ausgenommen unterpulvergeschweißter) Stahlrohre zum Nachweis von Fehlern

This European Standard was approved by CEN on 6 October 1999.

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Central Secretariat: rue de Stassart, 36 B-1050 Brussels

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CONTENTS

Page

Foreword

This European Standard has been prepared by Technical Committee ECISS/TC 29 "Steel tubes and fittings for steel tubes", the Secretariat of which is held by UNI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2000, and conflicting national standards shall be withdrawn at the latest by May 2000.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association. This European Standard is considered to be a supporting standard to those application and product standards which in themselves support an essential safety requirement of a New Approach Directive and which make reference to this European Standard.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This Part of EN 10246 specifies the requirements for automatic eddy current testing of seamless and welded tubes with the exception of submerged arc-welded (SAW) tubes for the detection of imperfections. The standard specifies acceptance levels, calibration procedures and gives guidance on the limitations of the tests.

This Part of EN 10246 is applicable to the inspection of tubes with an outside diameter equal to or greater than 4 mm.

European Standard EN 10246 "Non-destructive testing of steel tubes" comprises the Parts shown in annex A.

2 Normative references

This Part of EN 10246 incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of those publications apply to this Part of EN 10246 only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 20286-2	ISO system of limits and fits - Part 2: Tables of standard tolerance grades and limit deviations for holes and shafts (ISO 286-2:1988)
ENV 10220	Seamless and welded steel tubes - Dimensions and masses per unit length
ISO 235	Parallel shank jobber and stub series drills and Morse taper shank drills

3 General requirements

3.1 The eddy current inspection covered by this Part of EN 10246 is usually carried out on tubes after completion of all the primary production process operations.

3.2 The tubes to be tested shall be sufficiently straight and free from foreign matter as to ensure the validity of the test.

4 Method of test

4.1 The tubes shall be tested by the eddy current test method for the detection of imperfections using one of the following techniques, as appropriate:

a) Concentric coil technique - full peripheral (see figure 1);

b) Rotating tube/pancake coil technique - full peripheral (see figure 2) ;

c) Segment coil technique - weld only (see figure 3).

It is recognized that there may be a short length at both tube ends which cannot be tested. Any untested ends shall be dealt with in accordance with the requirements of the appropriate product standards.

NOTE: For the guidelines of limitations of the eddy current test method, see annex B.

4.2 When testing tubes using the concentric coil technique, the maximum outside diameter of the tube to be tested is restricted to 177,8 mm.

The relative speed during testing shall not vary by more than ±10 %.

NOTE 1: It is emphasized that the test sensitivity is at a maximum at the tube surface adjacent to the test coil and decrease with increasing thickness (see annex B).

NOTE 2: Square and rectangular tubes, used for structural purposes, with a maximum dimensions across the diagonal of 177,8 mm may also be tested using this technique.

4.3 When testing using the rotating tube/pancake coil technique, the tube and the pancake coil(s) shall be moved relative to each other so that the whole of the tube surface is scanned. There is no restriction on the maximum outside tube diameter using this technique.

The relative speed during testing shall not vary by more than ±10 %.

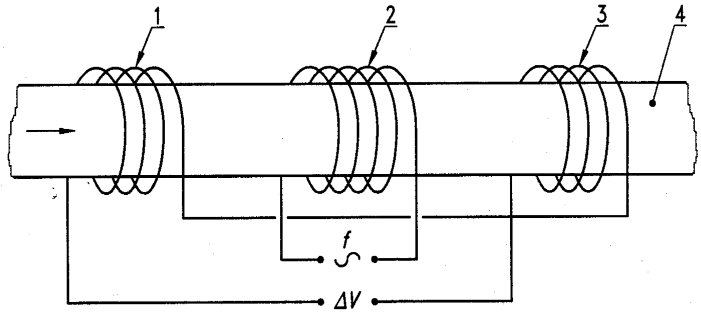
NOTE : It is emphasized that only external surface breaking imperfections can be detected using this technique.

4.4 When testing the weld of welded tubes using the segment coil technique, the test coil shall be maintained in proper alignment with the weld, such as that the whole of the weld is scanned. There is no restriction on the maximum outside tube diameter using this technique.

The relative speed during testing shall not vary by more than ±10 %.

NOTE : It is emphasized that the test sensitivity is at a maximum at the tube surface adjacent to the test coil and decreases with increasing thickness (see annex B).

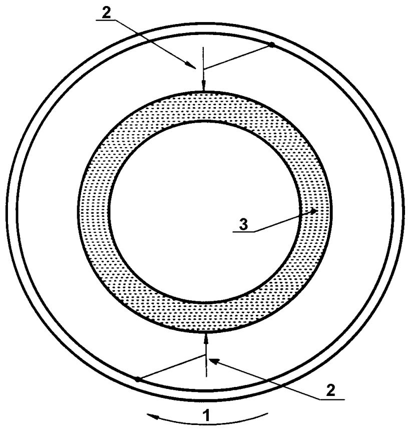
4.5 The equipment shall be capable of classifying tubes as either acceptable or suspect tubes by means of an automatic trigger/alarm level combined with a marking and/or sorting system.

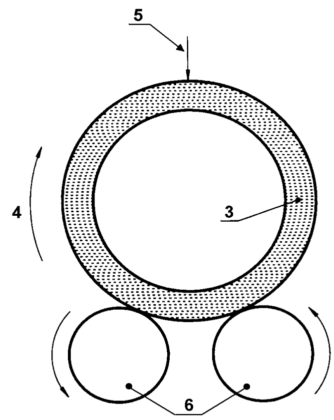


1= secondary coil 1 2= primary coil 3= secondary coil 2 4= tube

NOTE: The above diagram is a simplified form of a multi-coil arrangement which may contain, for example, split primary coils, twin differential coils, a calibrator coil.

Figure 1: Simplified diagram of the concentric coil technique





(a) Rotating pancake coil technique

(linear tube movement through the rotating pancake coil assembly)

(b) Rotating tube technique

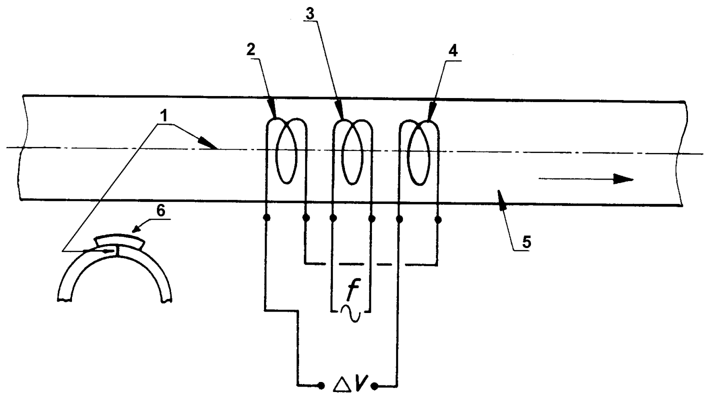
(linear pancake coil traverses along the tube length or fixed coils during helical movement of tube)

1= pancake coil rotation; 2= pancake coil; 3= tube

4= tube rotation 5= fixed pancake coil; 6=turning rolls

Note: The pancake coils in a) and b) may have different forms, e.g. single-coils, multiple coils of different configurations, depending on the equipment used and other factors.

Figure 2: Simplified diagram of the rotating tube/pancake coil technique (helical scan)



1= weld seam	2= secondary 1	3= primary
4= secondary 2	5= tube	6= coil

NOTE: The segment coil arrangement in the above diagram may take many forms depending, for example, on the equipment used and the product to be inspected.

Figure 3: Simplified diagram of segment coil testing method of the weld seam

5 Reference standards

5.1 General

5.1.1 The reference standards defined in this Part of EN 10246 are convenient standards for calibration of non-destructive testing equipment. The dimensions of these standards should not be construed as the minimum size of imperfections detectable by such equipment.

5.1.2 The testing equipment shall be calibrated using a reference standard introduced into a tubular test piece. The test piece shall be of the same specified diameter, thickness and surface finish as the tube to be tested and shall have similar electromagnetic properties.

NOTE: In special cases, for example testing hot tubes or using equipment contained within a continuous tube mill, a modified calibration or calibration checking procedure can be used, by agreement.

5.1.3 The reference standards for the various testing techniques shall as follows:

a) a reference hole or holes as defined in 5.2 when using the concentric coil technique;

b) a reference hole or holes as defined in 5.3 when using the segment coil technique;

c) a reference notch as defined in 5.4 when using the rotating tube/pancake coil technique.

5.2 Concentric coil technique

5.2.1 When using the concentric coil technique, the test piece shall contain three circular holes, drilled radially through the full thickness of the test piece. The three holes shall be circumferentially displaced 120° from each other, and shall be sufficiently separated longitudinally and from the ends of the test piece so that clearly distinguishable signal indications are obtained.

Alternatively, only one hole shall be drilled through the full thickness of the test piece and during calibration and calibration checking the test piece shall be passed through the equipment with the hole positioned at 0°, 90°, 180° and 270°.

5.2.2 The diameter of the drill required to produce these holes depends on the tube outside diameter as shown in table 1.

The diameter of the reference hole or reference holes shall be verified and shall not exceed the specified drill diameter by more than 0,1 mm for drill diameters less than 1,0 mm and by more than 0,2 mm for drill equal to or greater than 1,0 mm.

Table 1: **Acceptance level designation and corresponding tube diameter related drill sizes to produce the reference holes (concentric coil/segment coil techniques)**

Specified outside diameter D [1)] mm	Acceptance level drill diameter [2)] mm			Specified outside diameter D [1)] mm	Acceptance level drill diameter [2)] mm
	E1H	E2H	E3H		E4H
$D \leq 10$	0,6	0,7	0,8	$D \leq 26,9$	1,2
$10 < D \leq 20$	0,7	0,8	1,0	$26,9 < D \leq 48,3$	1,7
$20 < D \leq 44,5$	0,8	1,0	1,3	$48,3 < D \leq 63,5$	2,2
$44,5 < D \leq 76,1$	1,0	1,2	1,6	$63,5 < D \leq 114,3$	2,7
$76,1 < D \leq 177,8$	1,2	1,4	2,0	$114,3 < D \leq 139,7$	3,2
$177,8 < D$ [3)]	1,2	1,4	2,0	$139,7 < D \leq 177,8$	3,7
				$177,8 < D$ [3)]	3,7

1) According to ENV 10220

2) Tolerances according to ISO 235 (jobber series) and EN 20286-2 (h8)

3) This applies only to the segment coil technique.

5.3 Segment coil technique

5.3.1 When using the segment coil technique, the test piece shall contain a single circular hole, drilled radially through the full thickness of the test piece.

5.3.2 The reference hole shall be sufficiently separated from the ends of the test piece, so that clearly distinguishable signal indications are obtained.

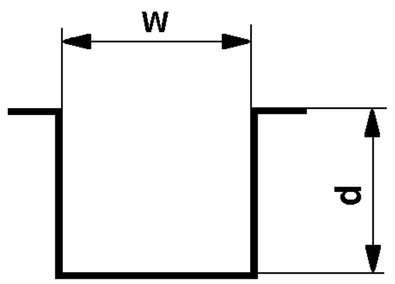
5.3.3 The diameter of the drill required to produce this hole depends on the tube outside diameter as shown in table 1. The diameter of the reference hole shall be verified as given in 5.2.

5.4 Rotating tube/pancake technique

5.4.1 When using the rotating tube/pancake technique, the test piece shall contain a longitudinal reference notch on the external surface.

5.4.2 The reference notch shall be sufficiently separated from the ends of the test piece, so that clearly distinguishable signal indications are obtained.

5.4.3 The reference notch shall be of the "N" type (see figure 4) and shall lie parallel to the major axis of the tube. The sides shall be nominally parallel and the bottom shall be nominally square to the sides.



w = width *d* = depth

Figure 4: "N" type notch

5.4.4 The reference notch shall be formed by machining, spark erosion or other methods.

NOTE: It is recognized that the bottom or the bottom corners of the notch may be rounded.

5.4.5 The dimensions of the notch shall be as follows:

a) the width *w* (see figure 4) shall not be greater than the depth of the reference notch depth;

b) the depth *d* (see figure 4) shall be as given in table 2, with the following limitations:

- minimum notch depth: 0,5 mm;
- maximum notch depth: 1,5 mm;

c) the tolerance on notch depth shall be ±15 % of the reference notch depth;

d) the length shall be at least twice the width of each individual transducer, with a maximum of 50 mm.

5.4.6 The reference notch dimensions and shape shall be verified by a suitable technique.

Table 2: Acceptance level designation and corresponding external reference notch depth (rotating tube/pancake coil technique)

Acceptance level	Notch depth in % of the specified thickness
E2	5
E3	10
E4	12,5
E5	15

Note. The values of notch depth specified in this table are the same for the corresponding categories, in all European Standards concerning non-destructive testing of steel tubes where reference is made to different acceptance levels. It should, however, be kept in mind that although the reference standards are identical, the various test methods involved can give different test results. Accordingly the acceptance level designation prefix E (eddy current) has been adopted to avoid any inferred direct equivalence with other test methods.

6 Equipment calibration and checking

6.1 The equipment shall be calibrated to produce consistently, (e.g. from three consecutive passes of the test piece through the equipment), clearly identifiable signals from the reference standard(s). These signals shall be used to set the trigger/alarm level of the equipment as follows.

a) When using multiple reference holes in the test piece (concentric coil techniques), the full amplitude obtained from the reference hole giving the smallest signal shall be used to set trigger/alarm level of the equipment. When using a single reference hole in the test piece, the test piece shall be passed through the inspection equipment with the reference hole, on successive runs, positioned as specified in 5.2 and the full amplitude obtained from the reference hole run giving the smallest signal shall be used to set trigger/alarm level of the equipment.

b) When using a single reference hole (segment coil technique for testing the weld of welded tubes), the full amplitude obtained from the reference hole run giving the smallest signal shall be used to set the trigger/alarm level of the equipment.

c) When using the reference notch (rotating tube/pancake coil technique), the full signal amplitude obtained from the reference notch shall be used to set the trigger/alarm level of the equipment.

6.2 During the calibration check, the relative speed of movement between the test piece and the test coil shall be the same as that to be used during production test. The same equipment settings, e.g. frequency, sensitivity, phase discrimination, rate filtering, magnetic saturation, shall be employed.

6.3 The calibration of the equipment shall be checked at regular intervals during the production testing of tubes of the same specified diameter, thickness and grade by passing the test piece through the test equipment.

The frequency of checking the calibration shall be at least every four hours but also whenever there is an equipment operator team changeover and at the start and end of production.

6.4 The equipment shall be recalibrated if any of the parameters which were used during the initial calibration are changed.

6.5 If on checking during production testing the calibration requirements are not satisfied, even after increasing the test sensitivity by 3 dB to allow for system drift, then all tubes tested since the previous check shall be retested after the equipment has been recalibrated.

7 Acceptance

7.1 Any tube producing signals lower than the trigger/alarm level shall be deemed to have passed this test.

7.2 Any tube producing signals equal to or greater than the trigger/alarm level shall be designated suspect, or at the manufacturer's option, may be retested.

7.3 If on retesting, no signals are obtained equal to or greater than the trigger/alarm level, the tube shall be deemed to have passed this test.

Tubes giving signals equal to or greater than trigger/alarm level shall be designated suspect.

7.4 For suspect tubes, one or more of the following actions shall be taken subject to the requirements of the product standard:

a) The suspect area shall be dressed or explored by a suitable method. After checking that the remaining thickness is within tolerance, the tube shall be tested as previously specified. If no signals are obtained equal to or greater than trigger/alarm level, the tube shall be deemed to have passed this test.

   The suspect area may be retested by other non-destructive techniques and test methods, by agreement between the purchaser and manufacturer to agreed acceptance levels.

b) The suspect area shall be cropped off. The manufacturer shall ensure that all the suspect area has been removed.

c) The tube shall be deemed not to have passed the test.

8 Test reporting

When specified, the manufacturer shall submit to the purchaser a test report containing at least the following information:

a) reference to this Part of EN 10246;

b) date of test report;

c) acceptance level;

d) statement of conformity;

e) product designation by grade and size;

f) type and details of inspection technique;

g) description of the reference standard.

ANNEX A
(informative)

Table of Parts of EN 10246 - Non-destructive testing of steel tubes

Purpose of test	Title of Part	Part no.	ISO ref.
Leak Tightness	Automatic electromagnetic testing of seamless and welded (except submerged arc-welded) ferromagnetic steel tubes for verification of hydraulic leak-tightness.	1	9302
	Automatic eddy current testing of seamless and welded (except submerged arc-welded) austenitic and austenitic-ferritic steel tubes for verification of hydraulic leak-tightness.	2	-
Longitudinal and/or transverse imperfections	Automatic eddy current testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of imperfections	3	9304
	Automatic full peripheral magnetic transducer/flux leakage testing of seamless ferromagnetic steel tubes for the detection of transverse imperfections	4	9598
	Automatic full peripheral magnetic transducer/flux leakage testing of seamless and welded (except submerged arc-welded) ferromagnetic steel tubes for the detection of longitudinal imperfections	5	9402
	Automatic full peripheral ultrasonic testing of seamless steel tubes for the detection of transverse imperfections.	6	9305
	Automatic full peripheral ultrasonic testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of longitudinal imperfections.	7	9303
	Automatic ultrasonic testing of the weld seam of electric welded steel tubes for the detection of longitudinal imperfections.	8	9764
	Automatic ultrasonic testing of the weld seam of submerged arc-welded steel tubes for the detection of longitudinal and/or transverse imperfections.	9	9765
	Radiographic testing of the weld seam of automatic fusion arc welded steel tubes for the detection of imperfections	10	12096
Surface imperfections	Liquid penetrant testing of seamless and welded steel tubes for the detection of surface imperfections.	11	12095
	Magnetic particle inspection of seamless and welded ferromagnetic steel tubes for the detection of surface imperfections	12	13665
Thickness	Automatic full peripheral ultrasonic thickness testing of seamless and welded (except submerged arc-welded) steel tubes.	13	10543
Laminar imperfections	Automatic ultrasonic testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of laminar imperfections.	14	10124
	Automatic ultrasonic testing of strip/plate used in the manufacture of welded steel tubes for the detection of laminar imperfections.	15	12094
	Automatic ultrasonic testing of the areas adjacent to the weld seam of welded steel tubes for the detection of laminar imperfections.	16	13663
	Ultrasonic testing of the tube ends of seamless and welded steel tubes for the detection of laminar imperfections	17	11496
	Magnetic particle inspection of the tube ends of seamless and welded ferromagnetic steel tubes for the detection of laminar imperfections.	18	13664

ANNEX B
(informative)

Guidelines notes on limitations associated with the eddy current test method

B.1 General

It should be noted that during the eddy current testing of tubes, the test sensitivity is at its maximum on the tube surface adjacent to the test coil and decreases with increasing distance from the test coil. The signal response from a subsurface or internal surface imperfection is thus smaller than that from an external imperfection of the same size. The capability of the test equipment to detect subsurface imperfections is determined by various factors, but predominantly by the thickness of the tube under test and the eddy current excitation frequency.

The excitation frequency applied to the test coil determines the extent to which the induced eddy current penetrates into the tube wall. The higher the excitation frequency the lower the penetration and conversely the lower the excitation frequency the greater the penetration; particular account should be taken of the tube physical parameters (e.g. conductivity, permeability).

B.2 Concentric coil/segment coil techniques

These test techniques are preferred since they can detect short longitudinal imperfections and transverse imperfections, both of which break, or lie below, the surface adjacent to the test coil.

The minimum length of the longitudinal imperfections which is detectable is principally determined by the search coil arrangement and by the rate of changes of section along the length of the imperfections.

B.3 Rotating tube/pancake coil technique

This test technique utilizes one or more pancake coils to describe a helical path over the tube surface. For this reason the technique detects longitudinal imperfections having a minimum length dependent on the width of the test coil and the inspection helical pitch. It is recognized that transverse imperfection are not normally detectable

Since the excitation frequency is significant higher than that using concentric coils, only imperfections which break the surface adjacent to the test coil are detectable.

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